DEFENSE PRODUCTS DIVISION
Fairchild Camera and Instrument Corporation
Robbins Lane, Syosset, New York

PROPOSAL NO. SME-CA-70

FOR

A VERTICAL ROCKET PHOTO SYSTEM

21 November 1958

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PROPOSED

AN ADAPTATION OF A SIMPLE AND RELIABLE SCANNING CAMERA FOR USE IN A VERTICAL FIRING ROCKET.

APPLICATIONS

RAPID VERY WIDE AREA SURVEILLANCE
RAPID METEOROLOGICAL SURVEY

ADVANTAGES

HIGH INFORMATION YIELD WITH LOW INVESTMENT IN VEHICLE AND WITH SMALL RISK
SHORT INFORMATION ACQUISITION TIME
FLEXIBILITY OF USAGE
LOW EQUIPMENT COST AND SHORT DELIVERY SCHEDULE

DESCRIPTION OF CAMERA

THE BASIC CAMERA PROPOSED FOR ADAPTATION IS SHOWN IN FIGURE 2. IT IS DESCRIBED IN DETAIL IN THE FOLLOWING PAGES. AS ADAPTED FOR A VERTICAL FIRING ROCKET, IT IS PROPOSED THAT THIS BASIC CAMERA BE CONFIGURED AS SHOWN IN FIGURE 5 OR FIGURE 6. THE PROS AND CONS OF THESE ALTERNATIVE CONFIGURATIONS ARE DISCUSSED IN THE FOLLOWING PAGES.

PHOTOGRAPHIC COVERAGE

THE ACHIEVABLE GROUND COVERAGE IS ILLUSTRATED IN FIGURE 3.
THE NATURE OF THE GROUND COVERAGE PATTERN IS SHOWN IN FIGURE 4.

DISCUSSION OF DESIGN PROBLEM

Figure 1 represents embodiment of a SIMPLE ROTARY PANORAMIC CAMERA in a 100 inch focal length. It is shown in its usual orientation; that is, with its optical axis parallel to the ground plane, with a single reflecting surface in front of the lens to direct the optical axis vertically downward. The instantaneous field of view of the lens is limited to a rectangular area determined by the film width in one direction and the width of an exposing slit in the other. Figure 1 serves to emphasize the major advantage of this type of camera: LARGE SCALE WIDE ANGULAR COVERAGE IN A SINGLE CAMERA. In this camera type the lateral angle is a matter of designer's choice.

This feature is accomplished as illustrated in Figure 2. Exposure is made by drawing film past the slit as the entire camera, including the magazine, rotates about its optical axis. This rotation is continuous in one direction, the angular velocity normally being a function of V/H and overlap requirements. Thus it is possible to scan continuously, 360° around the flight line, with all parts of the camera moving uniformly without intermittencies of any kind. Film velocity from supply, through the exposing slit to take-up spool in this case would be constant. However, since scan angles greater than 180° (horizon to horizon) are seldom required, it is necessary to move film across the slit during only part of the rotation. The spools themselves, however, continue to turn, feeding and taking up film at an average rate which furnishes the amount required for the portion of the rotation during which photography occurs. Chambers for the slack film are provided on each side of the slit. Referring to Figure 2, the transport cycle proceeds as follows:

Film is drawn from the Supply Spool by a pair of pinch rollers turning at a speed which is integrally tied to the rotational speed of the camera, which in turn is proportional to V/H. The film then passes under a roller attached to the Scan Stop Switch, thence through the Pressure Plate assembly around the Metering Drive Roller, an idler roller, and onto the Take-up Spool. The metering roller is mounted on a rocking member in such a way that is does not contact the film except during the scan period. This roller is continuously driven at a speed proportional to the camera rotation. It is brought into contact with the film by the Solenoid (shown schematically) when the camera reaches the point selected for starting the scan. The film previously accumulated in the supply chamber is then drawn past the exposing slit at a speed which is synchronous with the image being swept across the slit by the rotating mirror. As the film runs out of the supply chamber it actuates the Scan Stop Switch, which de-energizes the Solenoid, causing the rocker arm to tilt counter-clockwise, disengaging the driving roller and engaging a fixed roller on the opposite side of the gate, which serves as a brake to hold the film from coasting or being fed across to the take-up spool when the latter takes out the slack loop which has been transferred into the take-up chamber.

The take-up spool is simply overdriven sufficiently to take out all the slack film before the next scan occurs. In a more refined version or where the mass of film is great, a second pair of pinch rollers would be used at the take-up side to meter the film to the spool at a rate which would keep the spool turning continuously.

Control of the supply loop by the above method prevents accumulative build-up, or loss by virtue of the fact that all the film (whether too much or too little) is withdrawn each cycle. The effect of a slight over or under supply is merely to add or subtract proportionately from the angle scanned.

Figure 2 indicates one way in which the entire camera can be rotated by a single drive motor. In this case a fixed sleeve which would be mounted to the aircraft structure or a mount as the case might be, supplies bearing support for the camera. A belt is used to couple the motor to the camera through a cut-out in the fixed sleeve. Driving of the various rotating members in the magazine is effected by a pinion which rolls on an internal ring gear fastened to the fixed sleeve.

In order to maintain the shutter speed through variations in V/H the adjustable slit mechanism will contain an overriding control, which will be actuated as a function of the rotational speed.

Other functions such as remote exposure control involving iris and/or the slit width are readily adaptable by usual servo methods. The only difference here is that all these items will be rotating continously about the optical axis.

As used in a vertical firing, spinning rocket the basic camera described above would be oriented with its optical axis perpendicular to the ground plane, as shown in Figures 6 and 7 or slightly oblique to the perpendicular, as shown in Figure 5. In any case a single reflecting surface would serve to aim the camera outward and downward. Although, in these figures the camera housing is shown separate from the rocket shell, it is pointed out that the camera and shell rotate together at the rocket spin rate. The rocket shell and camera housing could be combined if this were considered advantageous.

In such an application, the camera could be used in its full 360° scanning mode with the film moving continuously past the exposure slit at a speed determined by the rocket spin rate and the focal length of the lens. Elimination of intermittency permits very high film transport rates. Thus, for a spin rate of 2 cycles per second, for example, a focal length of 24 inches can be employed. (The accompanying sketches and ground coverage patterns are based on a 24 inch focal length lens.)

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The continuous 360° scan appears to be appropriate when seeking coverage to a maximum radius ("looking over the fence"). In this case, the amount of film supplied and its programming would be such that photography would be accomplished as high up in the rocket trajectory as vehicle wobble would permit. In such a mission maximum focal length is indicated and the consequent high film transport rates require continuous rather than intermittent film handling.

For general coverage, i.e., to achieve as much as possible of the potential coverage shown in Figure 3, programming should probably be in a series of bursts in order to obtain optimum overlap and conserve film.

For high photographic acuity or for a more elaborate mission serving precise target location or photogrammetric purposes, camera attitude control would be required to make the camera independent of vehicle wobble.

The simplest embodiment of the rotary panoramic camera in a spinning rocket would be as shown in Figure 7, where the prism is fixed. In this case, however, the blind area directly beneath the rocket is quite large as shown.

This leads to consideration of rotating the prism as shown in Figure 6, or in bumping out the window and rotating the prism as shown in Figure 5. If such a window is tolerable, it reduces the blind area to a minimum. This approach shown in Figure 5 is the basis for the typical ground coverage pattern in Figure 4.

It is pointed out that the latter approach and the coverage obtained requires only four 360° scans and, with the 24 inch lens, only 50 feet of film. Thus, the complete picture is made in 2 seconds. (Actually the pattern was computed on the basis of the Aerobee-Hi Rocket in the first 2 seconds after burn-out.)

This then, might be considered one extreme condition. It would probably be more advantageous to use more than 4 scans, and to decrease the prism scan rate accordingly, to obtain more overlap. This would insure complete coverage in spite of vehicle wobble and errors in rocket velocity and altitude.

As in any panoramic camera, the lens is used almost entirely on axis which permits the lens design to be of much higher acuity for a given weight and cost. With modern large aperture lenses and high speed emulsions, fast shutter speeds can be obtained. Speeds upwards to 1/4000 second are practical. Such equivalent shutter speeds go a long way toward reducing the amount of "smear" resulting from image degrading moments.

In the simplest installation, the equipment required in addition to the basic rocket will be, of course, the camera, spin rate sensor combined with camera control unit, a power package, consisting of either one-shot or reuseable batteries, tracking beacons, and parachute. As mentioned above for very long range photography, where the absolute maximum information content is desired at extremely high altitudes, it would be desirable to equip the rocket with a miniature inertial system to aid in stability correction and to eliminate wobble.

In a more advanced configuration, the camera installation can be designed to take pictures in a series of linear scans across the terrain normal to the line of flight, making use of a horizontal position of the rocket during the period when it is at the top of a ballistic trajectory.

Obviously, the camera used can be calibrated and can be designed to record certain information such as real time, spin rate, film rate and stability conditions. To make use of photography from this rocket reconnaissance, special ground handling equipment in terms of developing, printing, projection, and most important of all, photo interpretation gear can be supplied and should be part of the system.

In the case of "non-spinning" rockets such as "ARCAS", "ARCON" and "IRIS" the photographic purpose could be served by a group of five miniature cameras utilizing existing wide angle lenses such as the 1-1/2 inch BIOGON. These cameras would be arranged in a cluster and would be operated in pulse ("single frame") mode to effect the full 360° coverage. Where the primary purpose is geodetic control then a 3 inch version of the new 6 inch BAKER lens could be employed. Presently, it appears that such a camera installation would require a rocket of the size of "IRIS".

DISCUSSION OF APPLICATIONS

This reconnaissance vehicle and its accompanying camera can be used for a number of very important military tasks.

A. In general fleet use, it can be used to survey the surrounding area for several thousand miles not only for objects on the surface but also for weather as expressed by extent and nature of cloud cover.

B. It can be used for meteorological research and as a routine aid for long distance forecasting.

C. It can be launched from portable platforms around the perimeter of areas of interest for the purpose of looking over the fence. This use will give information in terms of:

1. General Intelligence

2. Weather Conditions

There is also a potential worth investigation for gathering information of sufficient accuracy to be used in geodesy for the tying in of known points with points on the other side of the fence whose location is not known.

D. This type of rocket reconnaissance can be used for such routine problems as the annual coverage of the North Atlantic Ice Pack, its extent, distribution, and probable break-up pattern.

For the purposes of illustration and presentation of this rocket reconnaissance system, it has been keyed to the Aerobee-Hi vehicle with a maximum altitude of 140 to 190 miles. Obviously, it can be applied to other rockets which are either not as big, or to more expensive types which go much higher.

Our installation dimensions and weight allowances, etc., have been based upon data kindly furnished to us by Aerojet-General.

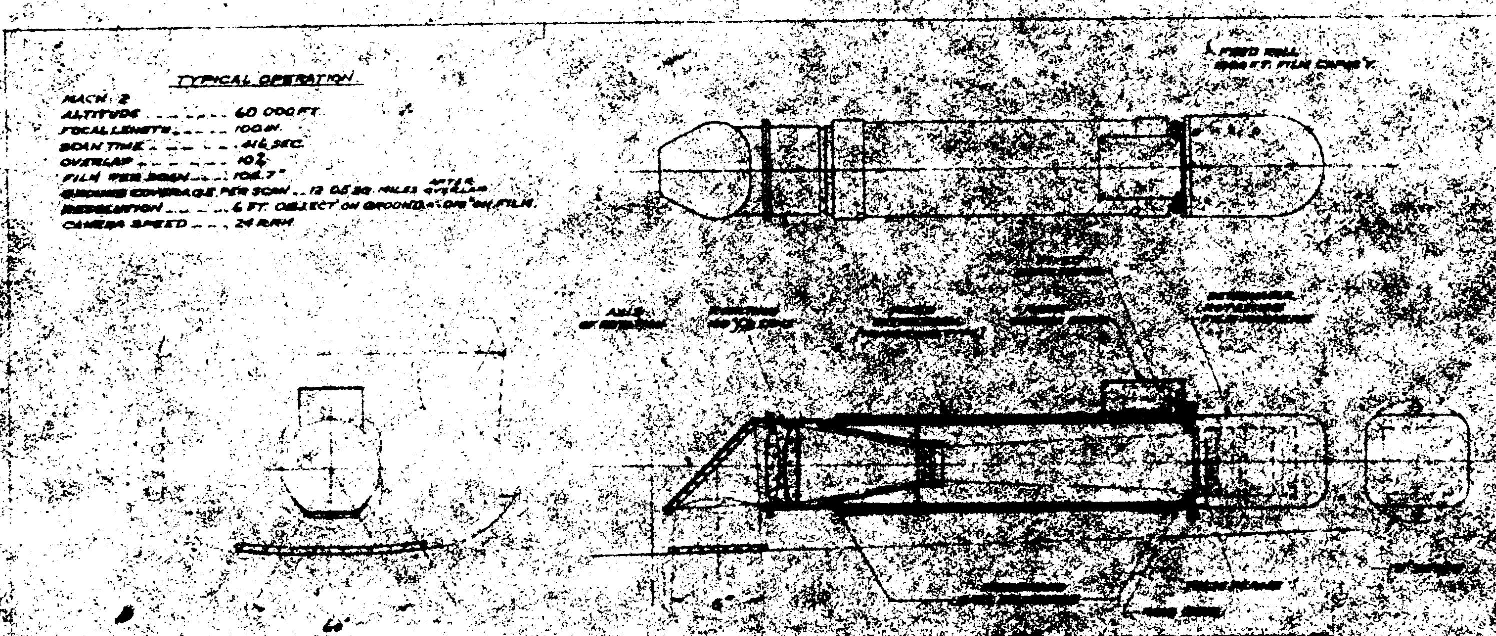
TYPICAL OPERATION
MACH 2
ALTITUDE .... 60 000 FT.
FOCAL LENGTH .... 100 IN.
SCAN TIME .... .416 SEC.
OVERLAP 10%
FILM PER SCAN .... 106.7"
GROUND COVERAGE PER SCAN ... 12.05 SQ. MILES AFTER OVERLAP
RESOLUTION .... 6 FT. OBJECT ON GROUND
CAMERA SPEED .... 24 RPM
60° SCAN
FAIRCHILD

FIG. 1

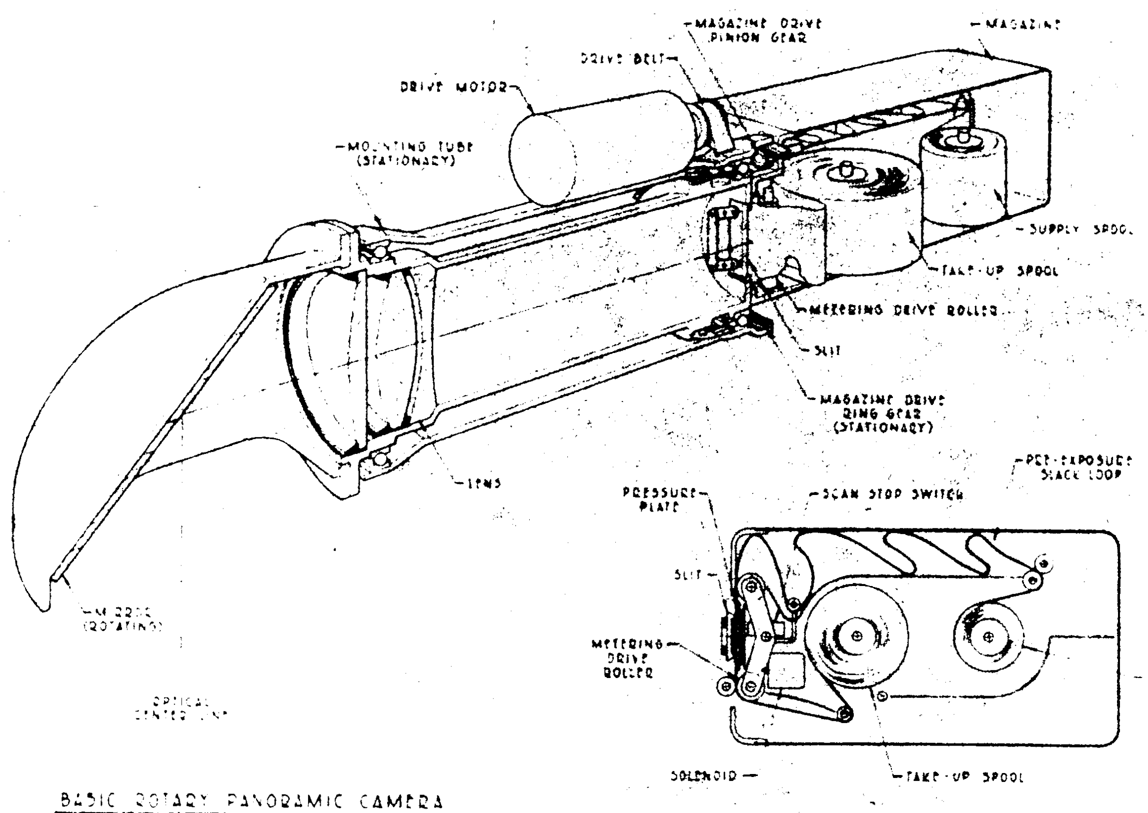

FIG. 2

FAIRCHILD

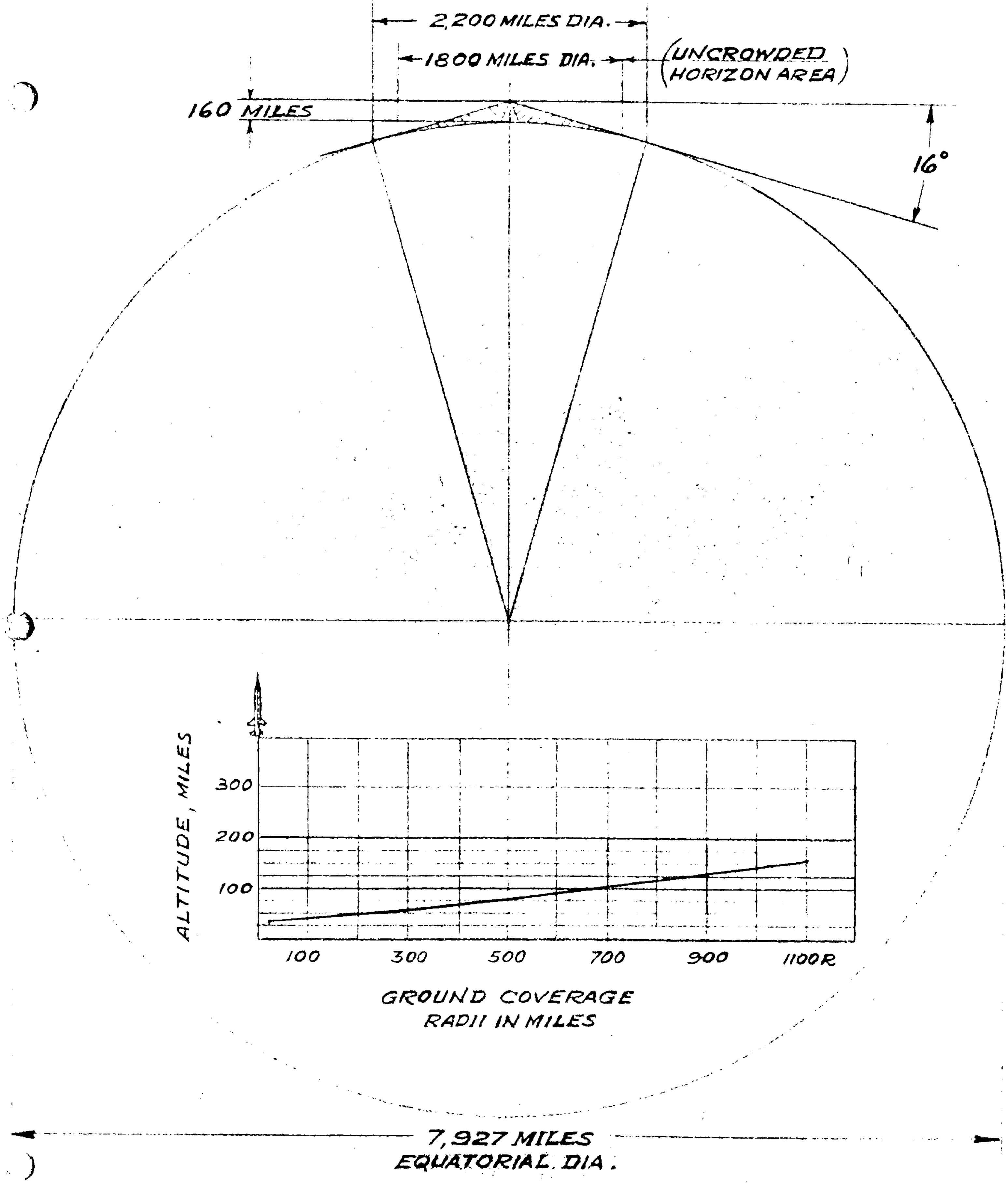

FIG. 3.

FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

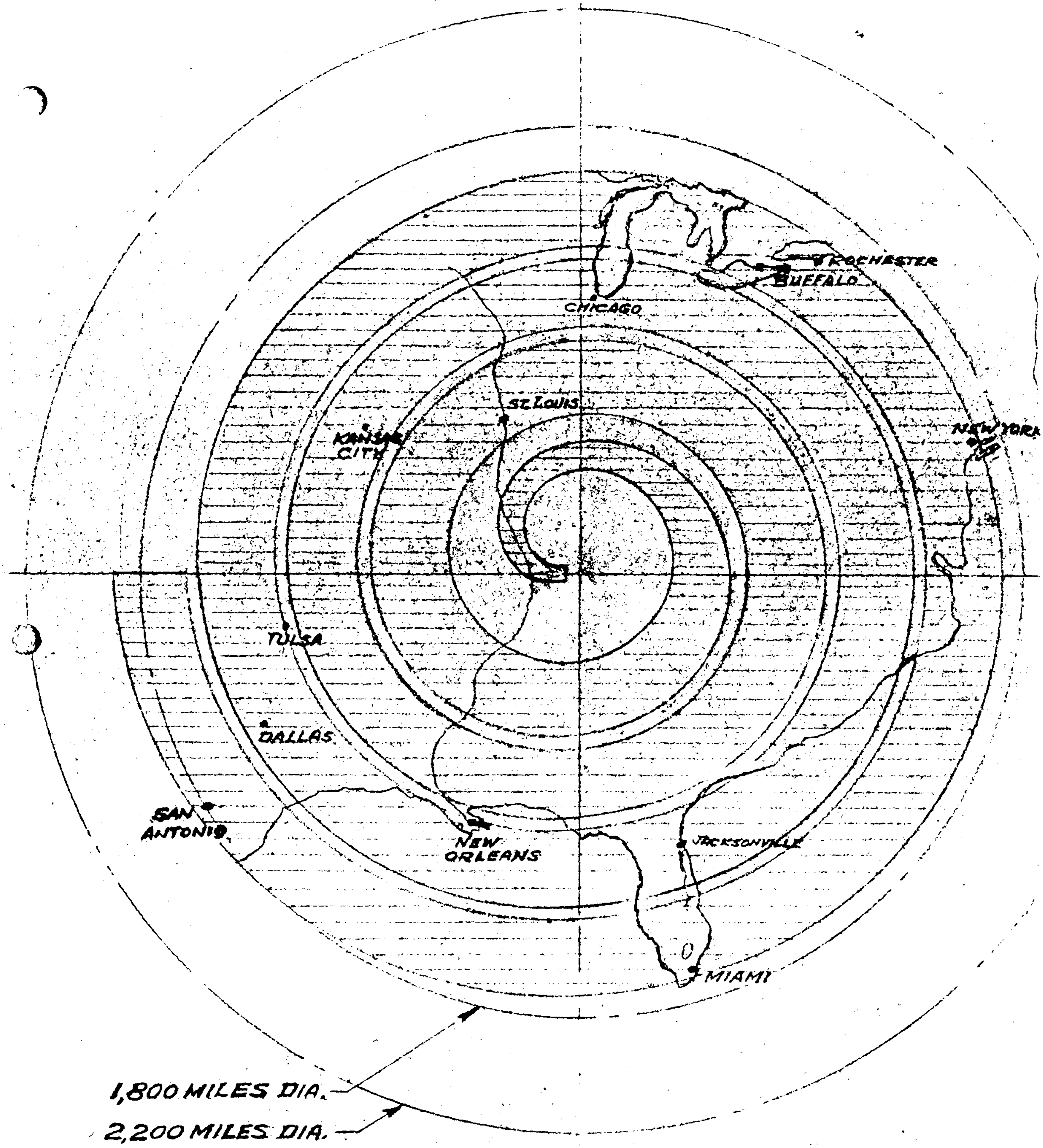

FIG. 4.

FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

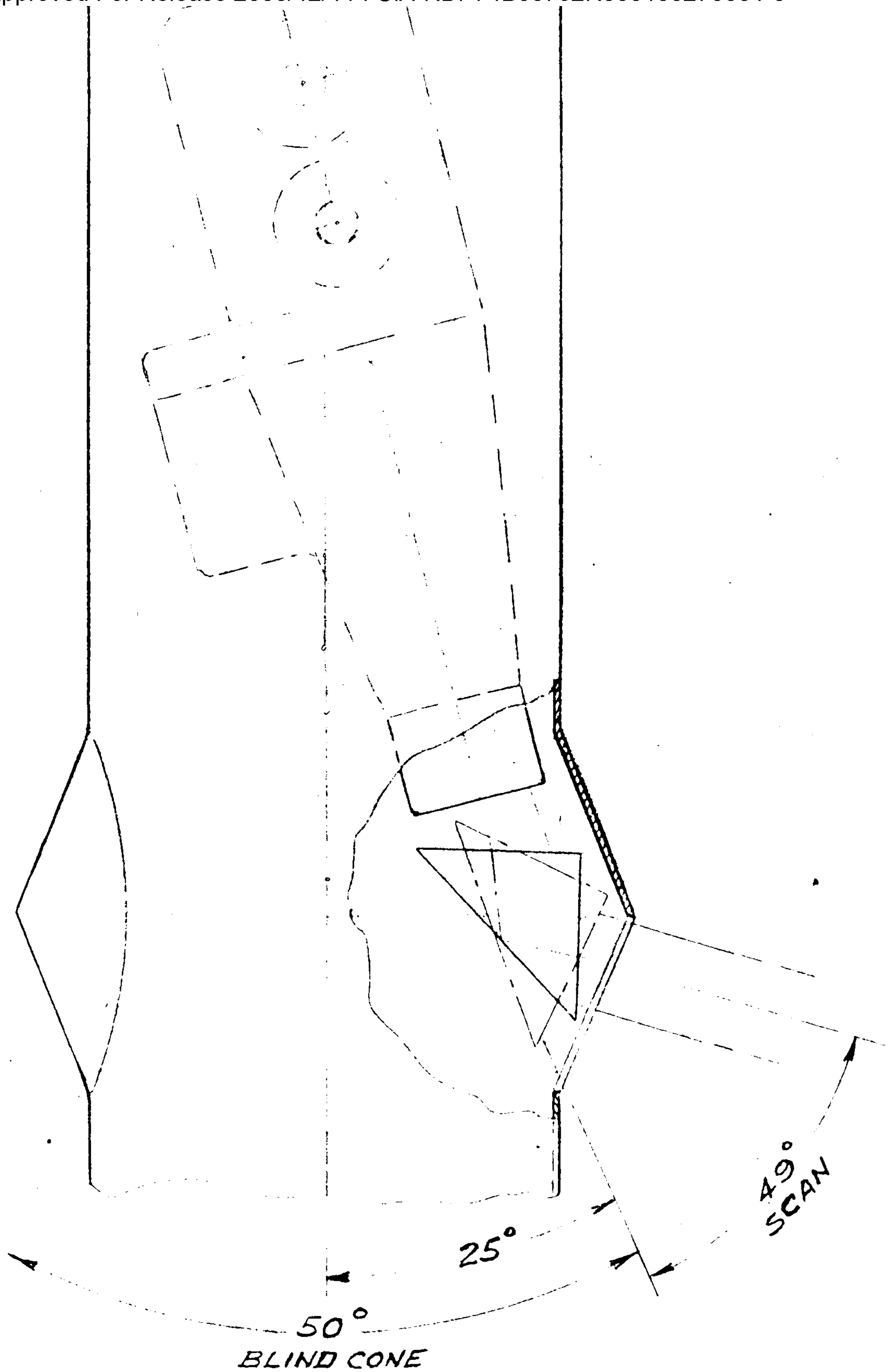

FIG.5.

FAIRCHILD
CAMERA AND INSTRUMENT
CORPORATION

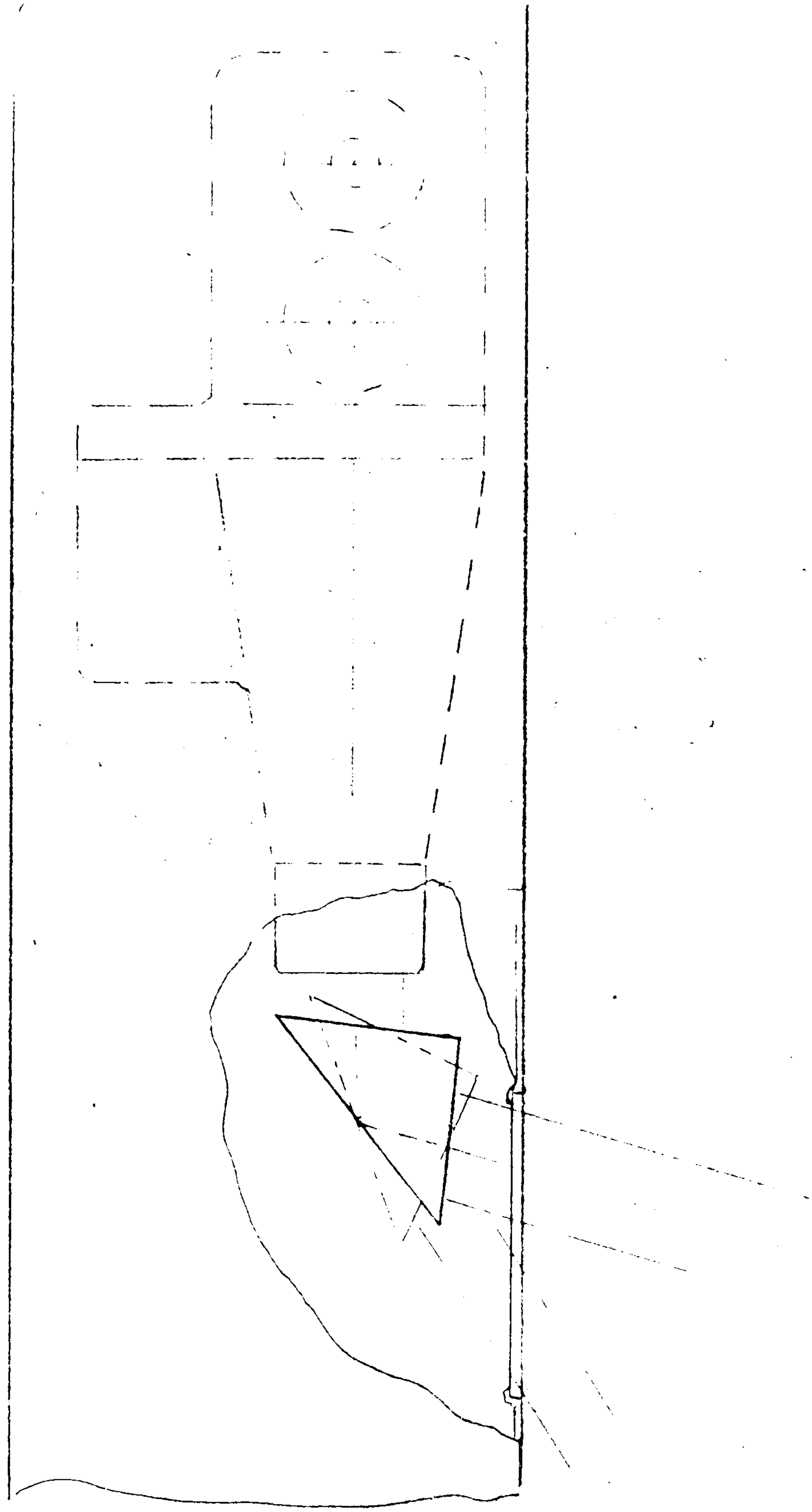

FIG. 6.

FAIRCHILD
CAMERA AND INSTRUMENT
CORPORATION

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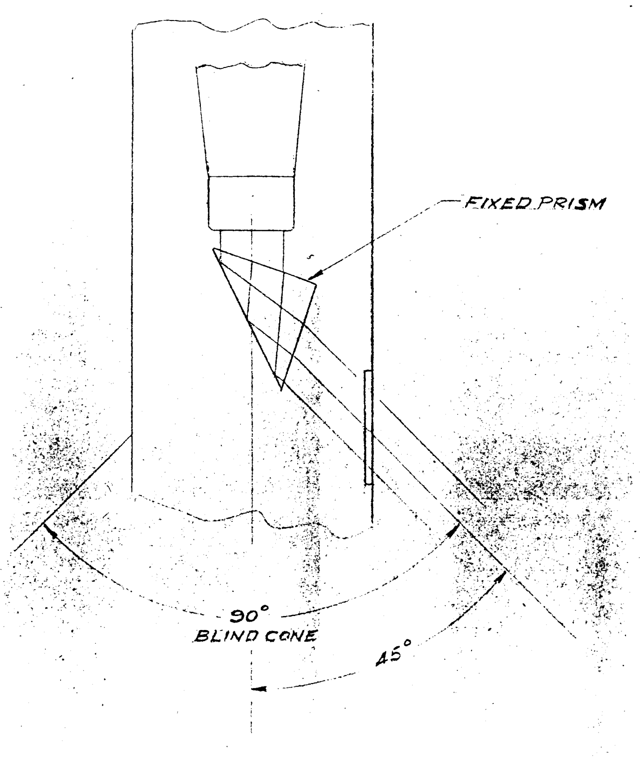

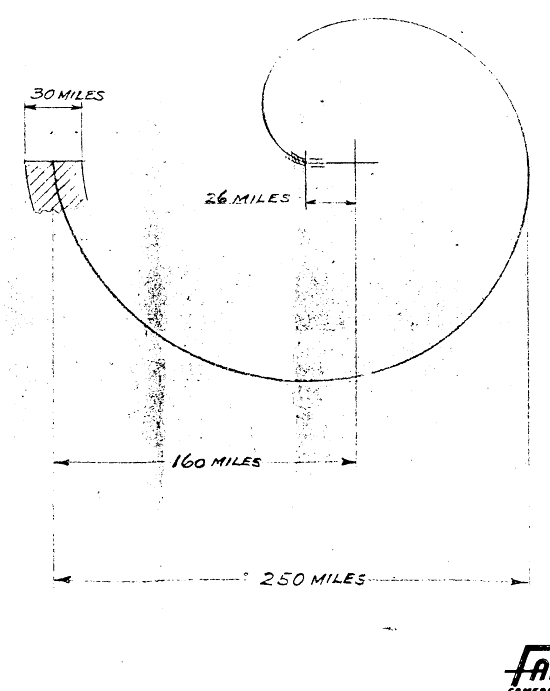

FIG.7

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CAMERA AND INSTRUM